

WORKING DRAFT

Salmonids: Central Valley Chinook Salmon ESUs, Central Valley Steelhead
Conservation Themes with Stressors, Impact Mechanisms, and Conservation Measure Concepts

Note: Information presented in this draft table is a preliminary work in progress and will continue to be refined based on new information as it is gathered. Citations and other documentation supporting the information will be provided in or appended to the table as more specific information is developed. This table was prepared by the following individuals at BDCP technical working sessions held on March 12 and March 16, 2007: Chuck Hanson (Hanson Environmental); Diane Wyndom, Bruce Oppenheim, and Rosalie del Rosario (NMFS); Jim White, Randy Baxter, Alice Low, and Neil Clipperton (DFG); Bill Harrell (DWR); Bill Bennett (UC Davis); Rick Sitts, David Fullerton, and Pete Rhoads (Metropolitan); Ron Kino (Mirant); and Campbell Ingram (TNC); and Pete Rawlings (SAIC). To prepare the information presented in this table, technical working session participants were requested to identify known and potential stressors without regard to the relative importance of and uncertainties associated with stressor effects and to identify potential conservation measure concepts without regard to their likely effectiveness in addressing stressors or their implementation feasibility. Life stages that could be affected by a stressor are indicated by an "X" in the table and life stages that are not believed to be affected by a stressor are indicated by a "0".

Conservation Theme	Stressor	Impact Mechanism	Life Stage					Conservation Measure Concepts
			Egg	Fry	Smolts	Adult		
1. Reduce sources of mortality								
1-1	SWP entrainment	<ul style="list-style-type: none">Entrainment into Clifton Court Forebay (CCF)¹Loss through louvers	0	X	X	X	<ul style="list-style-type: none">Install fish screens²Improve louversReal-time/Seasonal operationsIncrease SJR inflowsImprove efficacy of Head of Old River barriers³ (this is stressor for smelt)Increase outflowRelocate intake and improve screening (multiple intakes, new channel)Prevent entry of fish into CCFImprove velocity management and louver guidanceModify radial gate structure/operationsIntertie between SWP and CVP, joint pumping, fill San Luis early to provide flexibility in operations, preferential diversion operations based on fish densities and lossesIncrease diversion capacity to improve operational flexibility	

¹ Salmonids have a better chance for survival/collection than smelt.

² It is unclear that screening is an effective measure to minimize entrainment losses.

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
1-1b	CVP entrainment	▪ Loss through louvers	0	X	X	X	<ul style="list-style-type: none"> ▪ Install fish screens ▪ Real-time/seasonal operations ▪ Relocate/design/operate agricultural barriers ▪ Improve efficacy of Head of Old River barriers.² ▪ Increase outflow ▪ Relocate intake and improve screening (multiple intakes, new channel) ▪ Rebuild or refurbish existing louver facility ▪ Intertie between SWP and CVP, joint pumping, fill San Luis early to provide flexibility in operations, preferential diversion operations based on fish densities and losses ▪ Increase SJR inflows
1-2	SWP/CVP salvage	▪ Collection, Handling, Transportation, Release (CHTR) mortality ⁴	0	X	X	X	<ul style="list-style-type: none"> ▪ Install fish screens ▪ Improve louver guidance ▪ Improve CHTR process ▪ Seasonal operations ▪ Relocate intake and improve screening ▪ Multiple release sites ▪ Different techniques for release (e.g., barge vs. truck) ▪ Predator control within the salvage process
1-3	CCF predation	▪ Predation	0	X	X	X	<ul style="list-style-type: none"> ▪ Predator management/removal ▪ Modify Forebay.⁵ ▪ Remove Forebay ▪ Install fish screens ▪ Relocate intake

³ This measure would be a stressor for smelt.

⁴ Directed primarily at post-release entrainment and predation mortality.

⁵ For example, install screen/leaky rock levee so fish pass quickly through narrower channel to salvage facility, increase velocity to reduce residence time, forebay bypass to allow fish to be removed before water enters forebay.

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
1-4	DWR owned diversions	<ul style="list-style-type: none"> Loss at unscreened diversions (check to confirm that unscreened diversions in the Delta are not being used) 	0	X	X	X	<ul style="list-style-type: none"> Install fish screens Consolidate diversions Remove diversion Seasonal operations
1-4b	DWR Operated Bypasses	<ul style="list-style-type: none"> Fish stranding⁶ 	0	X	X	X	<ul style="list-style-type: none"> Build fish passage Regrade to improve drainage Recover stranded fish and move past barrier
1-4c	DWR Operated Bypasses	<ul style="list-style-type: none"> Upstream passage barrier delays migration sufficiently to result in mortality 	X	0	0	X	<ul style="list-style-type: none"> Build fish passage Recover stranded fish and move past barrier Screen to prevent fish access⁷
1-5	USBR owned diversion (Rock Slough-CCWD uses)	<ul style="list-style-type: none"> Loss at unscreened diversion 	0	X	X	0	<ul style="list-style-type: none"> Install fish screens Consolidate diversions Remove diversion Seasonal operations Encase Rock Slough canal
1-6	Private unscreened diversions (e.g., agricultural diversions)-(add ag islands)	<ul style="list-style-type: none"> Entrainment loss 	0	X	X	0	<ul style="list-style-type: none"> Install fish screens Consolidate diversions Remove diversion Seasonal operations
1-6b	Mirant Pittsburg and Contra Costa power plants	<ul style="list-style-type: none"> Entrainment losses Exposure to thermal discharge plume 	0	X	X	0	<ul style="list-style-type: none"> Retire/replace power plant units equipped with off-stream cooling Install improved fish screens Consolidate diversions Remove diversion Seasonal operations Reduce discharge temperatures Optimize variable speed circulating water pump drive (VSD) operations

⁶ This is also a stressor and impact mechanism for green sturgeon.

⁷ It may not be feasible to screen bypasses because of bypass width and magnitude of high flows.

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
1-7	North Bay Aqueduct	▪ Entrainment	0	0	0	0	None
1-8	Exposure to toxics	▪ Chronic and acute mortality	X	X	X	X	<ul style="list-style-type: none"> ▪ Source control ▪ Point-source reduction ▪ Non-point source reduction ▪ Sediment removal/capping/avoid resuspension ▪ TMDL ▪ Increased enforcement ▪ Modify pesticide/herbicide technology (shift to less toxic methods)
1-9	Predation ⁸	▪ Predation	0	X	X	0	<ul style="list-style-type: none"> ▪ Predator management/removal ▪ Increase cover habitat ▪ Reduce ambush points ▪ Avoid future non-native introductions ▪ Modification of channel geometry (where hotspots for predation, (e.g., split of Old River))
1-10	Propeller entrainment by cargo vessels	<ul style="list-style-type: none"> ▪ Entrainment mortality ▪ Increased vulnerability to predation ▪ Wake disturbance 	0	X	X	0	<ul style="list-style-type: none"> ▪ Increase off channel habitat ▪ Reduce vessel transit through Delta ▪ Increase channel width
1-11	Legal Harvest	<ul style="list-style-type: none"> ▪ Human take of individuals (ocean/freshwater) by various means ▪ Physical loss of eggs in redds as a result of wading 	X	0	0	X	<ul style="list-style-type: none"> ▪ Regulatory actions (e.g., including mass marking, mark selective fishery, size selective fishery). ▪ Buy out (retire) commercial licenses ▪ Close salmon redds to steelhead fishing/wading access (issue for salmon) ▪ Promote catch-release ▪ Public outreach

⁸ Focus is on conditions that create non-natural heightened vulnerability to predation (i.e., “ambush points”; including barriers, in-channel structures, and any other physical in-channel features that attract the species, but also attract and conceal predators).

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
1-11b	Illegal harvest	<ul style="list-style-type: none"> Human take of individuals (ocean/freshwater) by various means 	X	0	0	X	<ul style="list-style-type: none"> Increased law enforcement Increased fines and penalties Increased prosecution Public outreach Reduce barriers and impediments to migration where adults accumulate Improve cover in holding pools
1-12	Insufficient food supplies/location	<ul style="list-style-type: none"> Reduced growth/health/starvation 	0	X	X	X	<ul style="list-style-type: none"> See Conservation theme 6
1-13	Disease	<ul style="list-style-type: none"> Infection of wild fish from hatchery fish Loss of fish in conservation hatcheries 	X	X	X	X	<ul style="list-style-type: none"> Improve disease control in hatcheries Discharge disinfection Reduce elevated water temperature.
1-14	DCC operations	<ul style="list-style-type: none"> Delay in upstream migration Delay in outmigration and increased predation resulting from entrainment into the central/south Delta 	0	X	X	X	<ul style="list-style-type: none"> Reoperate DCC to improve migration success and survival
1-15	Water temperature	<ul style="list-style-type: none"> Direct egg, fry, and smolt mortality Direct mortality of adults (i.e., prespawning spring-run/fall-run) Shift in timing of spawning, emergence, etc. 	X	X	X	X	<ul style="list-style-type: none"> Modify upstream reservoirs to provide for cold water releases (multi-level temperature control device) Modify release operations Coldwater pool management in reservoirs Reestablish SRA in key locations (e.g., holding pools) Augment with cold groundwater flows Increase access to cold water reaches Expansion of Shasta to provide for coldwater releases Seasonal blending of releases for temperature management

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
1-16	Monitoring	Direct mortality	0	X	X	X	<ul style="list-style-type: none"> Stop monitoring Change monitoring techniques Target monitoring to avoid redundancy Implement BMPs for handling and release of fish (e.g., better gears to reduce mortality) Improve permit compliance
2. Increase species production (reproduction, growth, survival)							
2-1	Insufficient food supplies/location	<ul style="list-style-type: none"> Reduced growth, health, starvation 	0	X	X	X	See Conservation theme 6
2-2	Reduced suitable spawning habitat	<ul style="list-style-type: none"> Insufficient spawning conditions (e.g., substrate, temp.) Superimposition of redds 	X	0	0	X	<ul style="list-style-type: none"> Enhance spawning substrate availability and/or quality Improve gravel supply Separate runs w/physical barrier Increase access to spawning habitats Improve flow conditions to increase habitat area, improve temp. etc. Reduce fine sediment erosion/deposition Encourage channel meander to improve gravel improvement
2-3	Reduced suitable rearing habitat	<ul style="list-style-type: none"> Elevated Water temperatures Increased vulnerability to predation Increased competition Reduced DO and other water quality parameters Reduction in carrying capacity Reduced shallow-water subtidal/intertidal habitat 	0	X	X	0	<ul style="list-style-type: none"> Reduce channel velocity Increase flood plain habitat Levee set-backs Riparian corridor enhancement Increase inputs of large woody debris and overhead cover Remove riprap Reduce predator "hot spots" Increased access to spawning habitat also increases access to rearing habitat Increase gravel and reduce deposition by fines to increase macroinvertebrate production

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
2-4 (seasonal)	Reduced suitable adult habitat (upstream riverine—holding habitat)	<ul style="list-style-type: none"> ▪ Unsuitable seasonal holding pools ▪ Insufficient spawning habitat ▪ False migration pathways resulting from Delta configuration 	0	0	0	X	<ul style="list-style-type: none"> ▪ Enhance spawning substrate availability and/or quality ▪ Improve gravel supply ▪ Separate runs w/physical barrier ▪ Increase access to spawning habitats ▪ Improve flow conditions to increase habitat area, improve temp. etc. ▪ Reduce fine sediment erosion/deposition ▪ Encourage channel meander to improve gravel improvement ▪ Operate DCC to reduce entrainment of salmonids into central Delta and movement upstream into north Delta ▪ Relocate intakes ▪ Modify upstream reservoirs to provide for cold water releases (multi-level temperature control device) ▪ Modify release operations ▪ Coldwater pool management in reservoirs ▪ Reestablish SRA in key locations (e.g., holding pools) ▪ Augment with cold groundwater flows ▪ Increase access to cold water reaches ▪ Expansion of Shasta to provide for coldwater releases ▪ Seasonal blending of releases for temperature management ▪ Increase quality and availability of adult habitat in upstream tribs

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
2-5	Sublethal exposure to toxics	<ul style="list-style-type: none"> Increased vulnerability to disease Reduced growth rates Increased vulnerability to predation Reduced reproductive success 	X	X	X	X	<ul style="list-style-type: none"> Source control Point-source reduction Non-point source reduction Sediment removal/capping/avoid resuspension TMDL Increased enforcement Modify pesticide/herbicide technology (shift to less toxic methods)
2-6	Competition	<ul style="list-style-type: none"> Reduced food supplies. Increased energy expenditure Potential displacement from suitable habitat 	0	X	X	X ⁹	<ul style="list-style-type: none"> Non-native species management/control Reduce/avoid future introductions Improve habitat for native riverine species Reduce habitat for non-native species Increase quality and availability of spawning and rearing habitat Increase access to upstream spawning and rearing habitat Reduce competition with hatchery produced salmon
2-7	Water quality problems (e.g., reduced DO)	<ul style="list-style-type: none"> Impediment/barrier to migration Increased physiological stress Reduced health/growth 	X	X	X	X	<ul style="list-style-type: none"> Reduce/eliminate/control BOD loading leading to low DO Increase flushing flows Storm water pre-treatment Reduce exposure to seasonally elevated temps (see measures for 2-4) Erosion control
2-8	Existing or New Levees	<ul style="list-style-type: none"> Extent of floodplain habitats reduced (exclusion of fish from habitat) 	0	X	X	X	<ul style="list-style-type: none"> Levee set backs Improved access/habitat within flood bypasses Flood shallow islands and channel margins
2-9	Altered hydrology	<ul style="list-style-type: none"> Insufficient flow (reduced area and volume of habitat, passage, etc) Seasonal timing of flow inconsistent with life stage requirements 	X	X	X	X	<ul style="list-style-type: none"> Restore seasonal natural hydrology Manage instream flow releases to optimize physical habitat for each life stage

⁹ Primarily intraspecific competition for spawning habitat.

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
2-10	Barriers to passage	<ul style="list-style-type: none"> Delay in migration Loss of access to spawning and rearing habitats Stranding upstream or downstream of barriers Disorientation and increased predation Superimposition of redds Prespawning exposure and mortality 	X	X	X	X	<ul style="list-style-type: none"> Remove dams and other barriers preventing access to spawning and rearing habitats Modify barriers to improve passage Construct alternate channels to bypass barriers Collect stranded fish and transport to locations upstream or downstream of barriers Increase flow to increase flow over low barriers Seasonal operation of barriers Modify seasonal salinity control structure in Suisun to reduce effects on migration
3. Increase habitat quality and availability							
3-1	Reduced sediment input (change in volume, quality, geomorphic processes)	<ul style="list-style-type: none"> Loss of spawning gravel inputs Sedimentation of redds with fines Reduced dynamics of physical process that affect foodweb and microhabitat conditions 	X	X	X	X	<ul style="list-style-type: none"> Increase range of flow variation (high highs that restore erosion processes) Reduce levee armor (in-Delta, upstream of Delta) Allow channel meander Beneficial sediment re-use Gravel augmentation Mechanically scoring armored beds to release sediment
3-2	Reclamation/conversion of wetlands ¹⁰	<ul style="list-style-type: none"> Reduction in the surface area and volume of aquatic habitat Reduction in organic production within estuary Reduction in water quality 	0	X	X	0	<ul style="list-style-type: none"> Levee set backs Flood islands Increased treatment of wastewater/storm water Increase tidally inundated wetlands Increase bypass habitats

¹⁰ Important if estuary is important for rearing, if not, then less important.

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
3-3	Land use changes (ag/urban development)	<ul style="list-style-type: none"> Increased wastewater discharges (baseline and stormwater flows) Increased infrastructure and hard points¹¹ Loss of habitat and sediment inputs if channels are leveed/armored to protect development/ag lands 	X	X	X	X	<ul style="list-style-type: none"> Increase requirements for discharge water quality parameters that adversely affect fish and other aquatic species Pre-treatment for stormwater discharges Increased enforcement <p>Develop and implement guidance for appropriate urban development in floodplains</p> <ul style="list-style-type: none"> Exclude development from floodplains Manage amount of industrial development Manage amount of agricultural development Limit the geographic area of development Identify and implement BMPs for urban uses/ag practices that affect habitat
3-4	Reduced seasonal transport flows	<ul style="list-style-type: none"> Reduced downstream transport and distribution of fry and smolts Seasonal co-occurrence of larvae, habitat, food supplies 	0	X	X	0	<ul style="list-style-type: none"> Increase seasonal flows in Delta tributaries and in-flow to Delta Increase seasonal Delta outflow Timed seasonal upstream releases to facilitate downstream migration
3-5	Reduced upstream attraction flows	<ul style="list-style-type: none"> Delays in upstream migration Reduced flushing flows False attraction/increased straying 	0	0	0	X	<ul style="list-style-type: none"> Increase seasonal Delta inflow from Sacramento and/or San Joaquin Rivers Time releases in regulated tributaries to enhance upstream migration above Delta Increase seasonal Delta outflow Increase variability, timing, magnitude, of flow Reduce interbasin transfer of flows Relocate intakes

¹¹ Hardpoints impede conservation opportunities up and down stream from structures.

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
3-6	Reduced riparian vegetation	<ul style="list-style-type: none"> Reduced overhead cover Reduced organic/energy inputs to the aquatic system Localized elevated water temperatures Increased erosion/sedimentation 	0	X	X	X	<ul style="list-style-type: none"> Increase food/energy production (see Conservation theme 6) Riparian corridor enhancement for SRA Preserve existing riparian vegetation Maintain overhead vegetation on levees/reduce removal of vegetation Design new levees and levee maint. To incorporate designs that permit growth and retention of SRA Provide for flows that support establishment and maintenance of native riparian vegetation See Stressor 3-1 for measures to address erosion/sedimentation
3-7	Channelized riprap levees	<ul style="list-style-type: none"> Increased water velocities Reduced shallow water habitat Reduced cover Increased vulnerability to predation Reduced hydraulic connectivity between river and floodplain habitat 	0	X	X	X	<ul style="list-style-type: none"> Remove existing levee armoring Reduce/avoid future riprap Employ bioengineering techniques for levee protection Levee setbacks/increased floodplain Recreate shallow water habitats in Delta Vegetate levees to improve velocity and cover conditions (e.g. instream large woody debris, innovative bank protection)

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
3-8	Expansion of non-native species (Egeria, Eichornia etc.)	<ul style="list-style-type: none"> Reduced habitat quality and increased vulnerability to non-native predators Reduced flow velocities Reduced turbidity Reduced water quality (DO) 	0	X	X	0	<ul style="list-style-type: none"> Expanded and enhanced eradication/control programs Reduce/avoid future introductions Promote habitat features favoring native species Salinity fluctuation, flow and timing to manage/control invasive (could require moving intake depending on approach)
3-9	Increased water depth (channel dredging; marinas, ship channels)	<ul style="list-style-type: none"> Reduced habitat suitability Increased velocity (water is accelerated thru deep channel portion of cross section) Reduced photic zone causing reduction in primary production 	0	X	X	X ¹²	<ul style="list-style-type: none"> Reduce dredging volume Reduce dredging locations Beneficial re-use of all dredge material for estuarine habitat Restore shallow-water habitats to offset effects
3-10	Levee failure in the Delta (future under failed levee conditions) ¹³	<ul style="list-style-type: none"> Flooded islands may be too deep for suitable aquatic habitat Increased risk of levee failure and adverse effects of entrainment onto island/delay in migration Increase vulnerability to predation 	0	X	X	X	<ul style="list-style-type: none"> Reduce practices leading to subsidence Increase sediment accretion using dredge sediment re-use, import sediment, import agricultural waste. Increase organic production and carbon sequestration through ag/wetland management (re-build peat) Increase size and height of levees

¹² Adults prefer shallower margins of channels for migration.

¹³ It is unclear if this is a stressor for salmonids.

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
3-11	Increases in temperature (global warming)	<ul style="list-style-type: none"> Increased seasonal water temperatures Reduced area/distribution of suitable habitat 	X	X	X	X	<ul style="list-style-type: none"> Restore wide belts of riparian vegetation adjacent to channels See measures proposed for Stressor 1-15
3-12	Changes in seasonal hydrology (climate change—diminishing snow pack, shift in rain cycle [earlier] resulting in accelerated snow melt and erosion)	<ul style="list-style-type: none"> Change in the seasonal timing/magnitude of migration flows 	X	X	X	X	<ul style="list-style-type: none"> Modify reservoir storage and release Build reservoirs for cool pool management Reservoir reoperation/conjunctive use Increase flexibility of reservoir operations See measures for Stressor 1-15
3-13.	Sea level raise	<ul style="list-style-type: none"> Increased water depth and further loss of shallow-water habitat Change in flows and salinity (salinity moves upstream) 	0	X	X	0	<ul style="list-style-type: none"> Reduce rate of subsidence Promote active sediment accretion Restore habitat upstream Rebuild peat Increase levee size Flood islands

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
3-14	Barriers to passage	<ul style="list-style-type: none"> Delay in migration Loss of access to spawning and rearing habitats Stranding upstream or downstream of barriers Disorientation and increased predation Superimposition of redds Prespawning exposure and mortality 	X	X	X	X	<ul style="list-style-type: none"> Remove dams and other barriers preventing access to spawning and rearing habitats Modify barriers to improve passage Construct alternate channels to bypass barriers Collect stranded fish and transport to locations upstream or downstream of barriers Increase flow to increase flow over low barriers Seasonal operation of barriers Modify seasonal salinity control structure in Suisun to reduce effects on migration
3-15	Future introduction of non-native species (add to smelt table)	Competition Predation Reduced food supplies Disease Water quality (see above)	X	X	X	X	None currently proposed.
4. Increase habitat diversity¹⁴							
4-1	Levee/reclamation	<ul style="list-style-type: none"> Loss of access to suitable habitat 	0	X	X	0	<ul style="list-style-type: none"> Remove levees Levee set-back Increase flood plain Modify flow operations to provide habitat over a wider range of flows Construct and operate passage facilities for upstream and downstream fish movement at control weirs Construct bypass channels around control structures for fish passage
4-2	Levee/reclamation	<ul style="list-style-type: none"> Loss of shallow water subtidal habitat Loss of low velocity shallow water riverine habitat 	0	X	X	0	<ul style="list-style-type: none"> Levee set-back Flood islands Design new or repaired levees to incorporate shallow water benches, riparian vegetation, and large woody debris Improve habitat conditions for fish within flood control bypasses

¹⁴ Relative to Themes 2 and 3, this theme is intended to address stressors associated with the current uniformity of habitats and improving resilience.

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
4-3	Levee/reclamation	▪ Loss of flood plain inundation	0	X	X	X	<ul style="list-style-type: none"> ▪ Levee set-back ▪ Breach channel margin levees ▪ Flood shallow islands ▪ Provide for channel meander in riverine reaches ▪ Lower floodplain surfaces within leveed reaches to allow for seasonal overbank flooding ▪ Lower bypass weirs to extend period bypasses maintain water (could be done if adjustable weirs are installed to allow for extended spilling into bypasses during appropriate periods to avoid stranding issues)
4-4	Levee/reclamation	▪ Loss of intertidal habitat	0	X	X	0	<ul style="list-style-type: none"> ▪ Levee set-back ▪ Breach channel margin levees ▪ Flood shallow islands ▪ Beneficial re-use of dredge material to create shallow-water and intertidal habitat
4-5	Levee/reclamation/land use changes	▪ Loss of riparian habitat	0	X	X	X	<ul style="list-style-type: none"> ▪ Bioengineering for levee protection ▪ Plant riparian vegetation ▪ Avoid vegetation removal
4-6	Salinity control/compliance ¹⁵	▪ Reduced salinity variability	0	?	?	?	<ul style="list-style-type: none"> ▪ Remove/relax existing salinity control requirements ▪ Modify seasonal inflow for greater salinity variation ▪ Modify seasonal Delta outflow for greater salinity variation
4-7	Upstream impoundment storage and instream flow releases Flood control operations	▪ Reduced hydrologic variability, timing, and magnitude ¹⁶	0 ¹⁷	X	X	X	<ul style="list-style-type: none"> ▪ Modify seasonal releases for greater hydrologic variation ▪ Modify seasonal Delta outflow for greater hydrologic variation ▪ Maintain net seaward flows

¹⁵ The effects of this stressor on salmonids is not clear, but systemic effects of current salinity regimes on non-natives, food, etc. suggests there are likely indirect effects. Discussed that smolt studies have shown loss of weight in salmon in past 10 years, but there is no historical data for comparison. This is likely a result of rapid movement (e.g., 2 weeks) through the Delta with high expenditure of energy with little nourishment. Postulated that under historical conditions, smolts may have lingered in the Delta, gaining body mass rather than apparently losing body mass under existing conditions.

¹⁶ Affects environmental cues that trigger migration and life stage transitions, seasonal synchrony with environment, and habitat structure)

¹⁷ Eggs would be affected if hydrologic variability is introduced in spawning habitats via dewatering or scouring of redds—hydrological variability in spawning habitats is currently dampened by reservoir operations relative to historical conditions.

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
5. Increase species resilience							
5-1	Reduced genetic integrity and diversity ¹⁸	<ul style="list-style-type: none">▪ Small spawning population▪ Hatchery production▪ Reduced seasonal and geographic isolation▪ Reduced number of independent populations within the ESUs	X	X	X	X	<ul style="list-style-type: none">▪ Reduce/avoid hatchery production▪ Manage hatchery production for genetic integrity▪ Increase habitat (theme 3);▪ Increase number of independent salmonid populations▪ Selective harvest (hatchery produced only)▪ Segregation weir to separate populations▪ Conservation hatchery to maintain genetic stock (if needed to maintain genetic stock in event of extinction or near extinction)▪ Increase access to upstream habitat▪ Reduce straying (e.g., reduce trucking fish to disparate waters, interbasin transfers of water, interception of SJR flows)▪ Increasing abundance of small populations▪ Increase food production (see theme 6)▪ Reduce mortality (see theme 1)
5-2	Reduced population abundance	<ul style="list-style-type: none">▪ Reduced genetic diversity▪ Reduced population resilience	X	X	X	X	<ul style="list-style-type: none">▪ Increase habitat (see theme 3)▪ Increase food production (see theme 6)▪ Reduce mortality (see theme 1)▪ See stressor 5-1
5-3	Reduced population geographic distribution	<ul style="list-style-type: none">▪ Reduced genetic diversity▪ Increased vulnerability to impacts	X	X	X	X	<ul style="list-style-type: none">▪ Expand distribution of suitable habitat▪ Increase habitat (theme 3);▪ Increase number of independent salmonid populations▪ Increase access to upstream habitat▪ Increase food production (see theme 6)

¹⁸ Need to know what the minimum number of fish and distribution that needs to be maintained to maintain genetic integrity for each salmonid ESU. This stressor may be combined with 5-4.

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
5-4	Reduction in independent populations	<ul style="list-style-type: none"> Reduction in genetic diversity Increased vulnerability to impacts and environmental extremes 	X	X	X	X	<ul style="list-style-type: none"> Expand distribution of suitable habitat (e.g., establish fish above upstream barriers)
5-5	Increased habitat stability ¹⁹	<ul style="list-style-type: none"> Reduced adaptation Reduced genetic diversity Increased vulnerability to impacts and environmental extremes 	0	X	X	X	<ul style="list-style-type: none"> Increase seasonal variation in flows (timing, duration, magnitude) within ranges that maintain key habitat areas See Theme 4 measures. Levee setbacks
5-6	Reduced habitat diversity	<ul style="list-style-type: none"> Reduced adaptation Reduced genetic diversity Increased vulnerability to impacts and environmental extremes 	X	X	X	X	<ul style="list-style-type: none"> See Theme 4
5-7	Reduced frequency of extreme events that stress the system	<ul style="list-style-type: none"> Reduced adaptation Reduced genetic diversity Increased vulnerability to impacts and environmental extremes 	X	X	X	X	<ul style="list-style-type: none"> Increase range of seasonal variation in Delta tributaries and in-Delta inflow, outflow, and salinity intrusion Levee setbacks

¹⁹ Salmonids are insulated from historical range of perturbations because of modified hydrology below reservoirs.

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
6. Increase food availability (phytoplankton, zooplankton, macroinvertebrates, forage fish, etc)							
6-1	Reduced organic/energy input (inflow from upstream and in-delta production)	<ul style="list-style-type: none">▪ Reduced riparian vegetation▪ Levee stabilization▪ Changes in land use▪ Upstream storage/diversions▪ Reduced waste water/nutrient inflow	0	X	X	0	<ul style="list-style-type: none">▪ Increase upstream flood plain▪ Levee set back▪ Increase wetlands▪ Point source organic lading▪ Return hatchery carcasses to river
6-2	Increased consumption by non-native species	<ul style="list-style-type: none">▪ Biomass conversion to non-native species	0	X	X	0	<ul style="list-style-type: none">▪ Non-native species control/management▪ Reduce rate of new introductions▪ Increase primary and secondary production▪ Provide habitat conditions favoring native species▪ Provide habitat disfavoring non-native species▪ Expanded and enhanced eradication/control programs▪ Salinity fluctuation, flow and timing to manage/control invasive (could require moving intake depending on approach)
6-3	Increased diversion of nutrients/production out of estuary	<ul style="list-style-type: none">▪ Removal of organic carbon and nutrients from estuary resulting in reduced primary and secondary production	0	X	X	0	<ul style="list-style-type: none">▪ Increase organic production▪ Reduce seasonal diversions upstream, Delta agriculture, SWP/CVP exports
6-4	Competition	<ul style="list-style-type: none">▪ Reduction in densities/abundance of native or suitable prey	0	X	X	0	<ul style="list-style-type: none">▪ Non-native species control/management▪ Reduce rate of new introductions▪ Provide habitat conditions favoring native species (gravel, SRA, etc.)▪ Provide habitat disfavoring non-native species▪ Increase availability of suitable habitat
6-5	Increased channel velocities/reduced hydrologic residence time	<ul style="list-style-type: none">▪ Reduced primary and secondary production	0	X	X	0	<ul style="list-style-type: none">▪ Reduce exports▪ Increase channel cross-sectional area▪ Relocate intake▪ Increase primary and secondary production

Conservation Theme	Stressor	Impact Mechanism	Life Stage				Conservation Measure Concepts
			Egg	Fry	Smolts	Adult	
6-6	Increased water depths relative to the photic zone	<ul style="list-style-type: none"> Reduced primary production 	0	X	X	0	<ul style="list-style-type: none"> Levee set-backs Flood islands Promote active sediment accretions Increase primary and secondary production

Citations

Citations and other documentation to support the information provided in this table will be identified and provided in or appended to this table.